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New Wine in Old Bottles

During our vacation in the heart of the country, we took the opportunity to visit an agricultural implement foundry and discussed with the foreman-in-charge the problems he is encountering. There are thirty men in his shops, including three bright apprentices—a reasonable proportion. The output is of the order of 20 tons per week, much of which is repetition work, and no jobbing orders are accepted; in fact, the firm is buying castings from outside. Thus, the foreman's major problem is increased production. The raw material situation is satisfactory, the scrap and coke available alike being excellent. The main trouble is that the shops are low and old fashioned with wooden rafters. For internal transport good use is made of mono-rails, whilst the metal patterns exhibit real craftsmanship in their construction. Up to now, beyond a few stripping devices, reliance has been placed upon hand moulding.

As a beginning to the solution of his problems, a large jar-ram turnover machine is being installed, and over it there is being erected a sand-supply hopper to be filled by a bucket elevator. This machine will make field mower wheels. Though the floor has not been allowed to "grow," it is possible by excavation to gain increased height, and the area between the new moulding machine and the cupola is to be spanned by a 2-ton crane.

Here then is the beginning of a mechanised production in a shop ill suited—like so many others—for such a development, yet it is a logical and evolutionary step. The foreman has in mind the Garrett Report, but it may be that a requisition to spend much money on dust removal plant would wreck his plans for modernisation. We gathered he felt that he must earn his money for the provision of amenities by more economic production. If this be so, it seems reasonable to us that, presuming the developments will be a success, a percentage of the savings achieved should be set aside for the installation of dust prevention and removal plant. It should not be forgotten that, intelligently carried out, the provision of certain categories of amenities can be made to show savings. For instance, in the type of plant we are illustrating, where each moulder is making a component or short range of components, absenteeism, which is sometimes due to lack of good working conditions, causes the flow of castings to the machine shop to get out of balance and, consequently, hampers the firm in its commitments to its customers. It seems germane to record here that at the moment the foundry industry is not too popular with the farmers, because of their inability to procure in reasonable time the essential spare parts for agricultural machinery. The remedy is either the creation of stocks in the market towns or the reopening of the village jobbing foundries. The problem of the agricultural implement foundry is not an isolated case; on the contrary, it is fairly general throughout the country. Thus, where permission for the installation of new plant can be obtained, we counsel that managements should allocate a fixed percentage of any savings for the later provision of amenities. Should the savings indicate that the policy is making a worthwhile contribution to the progress of the whole business, then serious consideration should be given to the rebuilding of the foundry department as soon as conditions allow. We fear that the installation of much dust prevention plant and the like would be putting new wine into old bottles.

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The Institute of Metals

Fortieth Annual Autumn Meeting

The Fortieth Annual Autumn Meeting of the Institute will be held at the Arts School, Bennet Street, Cambridge, from September 14 to 17, 1948. An interesting series of visits and excursions has been arranged, and the Council hopes that there will be a large attendance.

Details of the programme are listed below:—

Tuesday, September 14

2.0 p.m. Office will open at The Arts School, Bennet Street, for the issue of tickets, badges, programmes and general information. 6.30 p.m. Service in the Church of St. Edward, King and Martyr. 8.0 p.m. to 11.0 p.m. Conversazione at The Old Schools, King's Parade.

Wednesday, September 15

9.45 a.m. Welcome by His Worship the Mayor of Cambridge, business meeting at The Arts School, Bennet Street. Discussion on: "The Micro-Hardness Testing of Metals," based on a paper by E. Wilfred Taylor, and Paper by G. A. Cottell, K.M. Entwistle and F. C. Thompson on: "The Measurement of the Damping Capacity of Metals in Torsional Vibration." 12.45 p.m. Luncheon. 2.0 p.m. Visits to laboratories, works and other local places of interest.

Thursday, September 16

9.45 a.m. Papers by J. S. Bowles and W. Boas on: "The Effect of Crystal Arrangement on 'Secondary Recrystallisation' in Metals"; by M. Cook and T. Ll. Richards on: "Observations on the Annealing Characteristics of an Aluminium-Copper-Magnesium Alloy"; 12.45 p.m. Luncheon. 2.0 p.m. Visits to laboratories, works, and other local places of interest; 6.0 p.m. The Autumn Lecture by Professor Sir Lawrence Bragg, O.B.E., M.C., on "The Cavendish Laboratory."

Friday, September 17

10.0 a.m. Visits for Members only to W. H. Allen, Sons & Co. Ltd., W. H. A. Robertson & Co. Ltd., Manganese Bronze & Brass Co. Ltd., Ipswich, or Stewarts & Lloyds Ltd., Corby.

Visitors will be welcome at all sessions of the Autumn Meeting. Persons whose applications for membership have been received and are under consideration will be eligible to attend the visits to works, etc.

Forthcoming Events

(Secretaries are invited to send in notices of meetings, etc., for inclusion in this column.)

SEPTEMBER 11.
Institute of British Foundrymen.
Newcastle-upon-Tyne Branch:—Presidential Address, followed by a Technical Film at the Neville Hall, Newcastle-upon-Tyne.

SEPTEMBER 13.
Institution of Production Engineers.
Manchester Graduate Section:—"The Lost Wax Process," by A. P. Short, at Reynolds Hall, College of Technology, Manchester, at 7.15 p.m.

SEPTEMBER 14.
Birmingham Graduate Section:—"The Romance of Carborundum," film at the James Watt Memorial Institute, Great Charles Street, Birmingham, at 7 p.m.

Conference on Foundry Core Bonding

Under the auspices of the British Iron and Steel Research Association there will be held, on October 21 and 22, a conference on foundry core bonding at Ashorne Hill, Leamington Spa. Under the chairmanship of Dr. W. J. Rees, O.B.E., the use of new materials for the bonding of cores will be discussed, and Papers relative to the supply of materials, mechanism of bonding, and laboratory and field trials will be presented.

Ferrous and non-ferrous founders, core compound manufacturers, and others in related fields are invited to attend. Reservations should be placed with the Technical Secretary, Steel Castings Division, British Iron and Steel Research Association, 11, Park Lane, London, W.1, by October 5. The programme of Papers and discussions is detailed below:—

Thursday, October 21

Assembly at 3.30 p.m., followed at 4.15 p.m. by the Chairman's introductory remarks; "A Review of the Natural Drying Oils," by Professor T. P. Hilditch (Liverpool University); "The Supply of Oils," by E. B. Harvey (Ministry of Food); "The Theory and Practice of Bonding,' by Dr. J. White (Sheffield University); "Plastic Materials as Bonding Agents," by Mr. J. M. J. Estevez (I.C.I.), and "Petroleum Derivatives as Bonding Agents," by Dr. H. K. Whalley (Manchester Oil Refineries).

Friday, October 22

9 a.m.—"Gases Evolved from Cores," by Mr. W. M. Lord (Sandholme Iron Company, Limited); "The Application of New Materials to Core Bonding in the Steel Foundry," by Mr. H. E. Crivan (The Clyde Alloy Steel Company, Limited); "Core Binders in the Iron Foundry," by Mr. E. C. Dickenson (Morris Motors, Limited); "The Use of Synthetic Resin Core Binders in Non-Ferrous Foundries," by Mr. G. L. Harbach (Worthington Simpson, Limited), and "Core Bonding Practice Abroad," by Mr. W. M. Lord (Sandholme Iron Company, Limited).

1 p.m.—"Dielectric Loss Heating and its Possible Future Application in the Foundry Industries," by Mr. C. E. Tibbs (Radio Heaters, Limited); "Infra Red Heating by Electricity," by Mr. J. C. Lowson (B.T.H.); "Infra Red Heating by Gas," by Mr. A. C. Jennings (Sheffield Gas Company, Limited), and "Core Blowing," by Mr. W. West (Leyland Motors, Limited).

THE STUDENTS' SECTION of the Birmingham, Coventry and West Midlands branch of the Institute of British Foundrymen held their first meeting of the session at the Chamber of Commerce, Birmingham, last night. Following the address by the Chairman, Mr. D. Marles, two films were shown. The first, "The Making of a Cast Crankshaft," was introduced by the President of the Institute, Mr. R. B. Templeton; the second was entitled "The Manufacture of Spun Iron Pipes."

The Solidification of Metals*

Fundamental Difficulties associated with Founding

By Dr. E. Scheuer, of International Alloys, Limited

Introduction

Casting can be defined as pouring molten metal into a hole and letting it freeze. It seems simplicity itself, but every foundryman and most users of castings know it is not at all simple. To the question why it is not simple, this lecture is devoted.

It is not proposed to deal with the more obvious difficulties of making a mould that stands up to the liquid metal and can be filled without splashing or of preventing lumps of slag or dross from finding their way into the mould. What the lecture is to describe is: Given the mould filled with the proper metal without contamination, why does one find defects in the casting which were not present in the liquid metal?

The answer is that the solidification of metals is by no means a simple process. It is proposed, therefore, first to turn to the characteristics of the process of freezing and after this to describe their connection with one of the most common defects in castings, namely, the cavities. Some glimpses of other phenomena in castings: The presence of gas and hot shortness can be dealt with in passing, but more cannot be usefully compressed into one lecture.

TABLE I.—*Solidification Shrinkage of Some Metals (after Sachs and van Horn, Practical Metallurgy).*

Metal.	Al.	Ag.	Au.	Bi.	Cd.	Cu.	Hg.	Mg.	Mn.	Na.	Pb.	Sb.	Sn.	Zn.
Shrinkage Percentage ..	6·45	5·0	5·2	−3·4	4·7	4·05	3·75	2·5	1·7	2·5	3·6	−0·95	2·9	4·5

The Physical Facts about Solidification

General Features:

There are three main features of the process of solidification of metals which are of interest for our purposes.

(1) Liquid metal on cooling does not gradually become more and more viscous and eventually solid, but a distinct new substance, solid metal, grows in the liquid metal and gradually replaces it. (Fig. 1.)

(2) A volume contraction accompanies the freezing of all metals normally used in the foundry. It ranges from 2.5 per cent. for Mg, to 6.5 per cent. for Al, as shown in Table I. That corresponds to 44 to 111 cub. in. per cub. ft. of metal. This is the maximum amount of shrinkage cavities one can expect. (Pattern-maker's shrinkage has nothing to do with it, such shrinkage results from the thermal contraction of the solid casting during cooling to room temperature.)

(3) During freezing a considerable amount of heat is set free, this is the latent heat of solidification. This has the effect of retarding or even arresting the drop in temperature whilst the metal is freezing, in spite of the cooling effect of the mould walls. The following figures tell roughly how much the temperature of a casting would drop during the time of freezing if no latent heat of fusion were to be carried away.

Metal.	Temperature difference equivalent to latent heat of fusion in deg. C. deg.
Al	412
Fe	602
Zn	267
Pb	209

Development of Metal Grains

The transition of the liquid metal to the solid form needs further consideration. Looking at it roughly, the freezing of a casting in many cases appears to consist in formation of a solid shell along the mould walls (which is the coolest part of the metal body), and this shell grows thicker and thicker until the two layers growing from opposite sides or the mould meet in the

FIG. 1.—SURFACE OF A TIN INGOT DURING SOLIDIFICATION IN A GRAPHITE DISH.

The sharp boundary between liquid portion (centre) and solid parts (rim) is shown. The boundary appears as a step and shows up brightly in the oblique illumination.

* A paper presented to the Slough Section of the London Branch of the Institute of British Foundrymen.

The Solidification of Metals

centre. This is, however, a simplification. One can get an idea of the real shape of the boundary between liquid and solid metal by pouring the liquid remainder out before all metal is frozen.

The general appearance of this boundary is more or less like Fig. 2. The solid metal grows in the shape of little trees or moss into the liquid. Each tree or dendrite (from the Latin word *dens* = a tooth) is pointed at the top and growing thicker and denser at the bottom (that is, at the mould wall end), and there they eventually grow together into one solid dense mass of metal.

In other cases the liquid produces separate grains of solid metal which first remain suspended in the liquid, but by growing at the same time thicker and more numerous transform the liquid first into a paste and eventually join rigidly together as they meet during growth (Fig. 3).

The shape and size of the dendrites is governed by two things:—(1) The nature of the metal (components and proportions of the mixture); and (2) the condition of the metal during freezing, especially the speed and direction of cooling. Very generally speaking, pure metals and slow cooling tend to favour larger and coarser dendrites, whilst mixtures of metals and high cooling speeds promote the formation of smaller and more ramified dendrites.

FIG. 2.—BOUNDARY BETWEEN LIQUID AND SOLID IN A FREEZING INGOT. (95 PER CENT. PB, 5 PER CENT. SN).
About two-thirds natural size.

Dendrites are to be seen growing from the wall. The liquid has been drained away in order to make the dendrites visible.

FIG. 3.—DENDRITES GROWING SUSPENDED IN THE LIQUID—PURE LEAD.
Natural size.

Top of ingot, natural size, showing also dendrites growing from the wall. The liquid has been partly drained away by shrinkage to expose the crystals in relief.

Mechanism of Crystallisation

Whilst the total quantity of metal freezing in a given time depends on the amount of heat carried away through the mould wall, the number and shape of crystals formed in this quantity depends on the interplay of nucleus formation and crystal growth. The crystals grow from nuclei, that is, very minute crystals, which form spontaneously in the liquid if it be cooled slightly below freezing point. Each nucleus, once formed, immediately starts growing, and goes on growing until it meets other crystals on the mould wall. Fig. 4 shows diagrammatically how the crystal grains can join up to form a solid mass of metal. If the cooling be intense, the formation of nuclei goes on rapidly in front of the growing crystals and they are not allowed to grow much before they are stopped by others (Fig.4 (a)). If the cooling be very slow, both formation of nuclei and the growth are slowed down, and, instead of small grains, large ones are formed having a very similar shape (Fig. 4 (c)).

At intermediate cooling rates, however, the formation of nuclei in front of the growing crystals is overtaken by the growth of crystals from the wall. As a result these go on growing and form long columns which eventually meet in the centre of the cast section (Fig. 4 (b)), unless the nucleus formation in the interior is brought into effect again as the increasing thickness of the shell reduces the cooling rate and with it the rate of growth of the columnar crystals.

Nuclei can also be produced in the melt as a result of certain additions to the metal. This method is frequently used, especially with aluminium and magnesium alloys, for the purpose of obtaining small crystals in spite of slow cooling rates. In many cases these nuclei are provided by the admixtures being precipitated, as compounds in finely divided form, from the liquid metal before the bulk of the metal starts freezing.

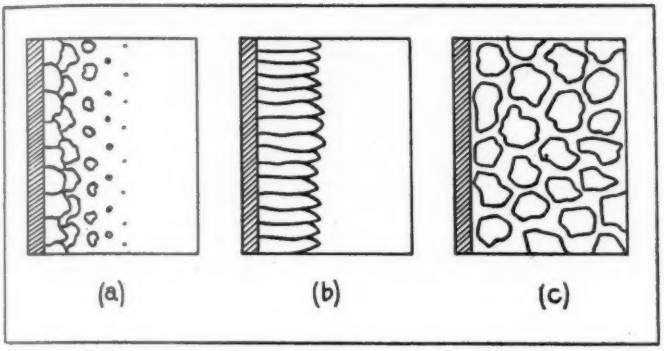

FIG. 4.—DIAGRAM SHOWING THREE KINDS OF BUILDING-UP OF A CAST STRUCTURE.
(*a*) Rapid cooling results in fine grain equiaxed. (*b*) Intermediate cooling results in columnar crystallisation. (*c*) Slow cooling results in coarse, equiaxed grain.
The hatched zone on the left represents the mould wall.

Two well-known cases of this kind are the addition of titanium to aluminium and aluminium alloys (Fig. 5) and the introduction (by overheating) of carbon (aluminium carbide) into magnesium alloys containing aluminium.[2]

Freezing of Alloys

The freezing of a mixture of metallic elements is considerably more complicated than that of a pure metal. Generally, the solids formed from a mixture differ in their composition from the liquid from which they form. Consequently, in order that a crystal can grow, certain components must travel towards its surface in the liquid and others away from it. This takes time, and the growth of crystals in alloys is generally slower than in pure metals, which results in smaller grain (Fig. 6). Another consequence is that normally the composition of the liquid and the solid and also the freezing temperature change continuously during the freezing. The temperature generally drops over a range from a few degrees to several hundred degrees and tends in many cases to come to a full stop towards the end of the solidification. Parallel to this the composition of the liquid between the growing "primary" crystals tends to become richer in the alloying additions and eventually stabilised at what is called the eutectic composition when a closely knit mixtuie of two or more kinds of crystals freezes out at constant temperature (eutectic temperature) much like a pure metal.

The layer of low-melting-point mixture which forms round each growing crystal not only prevents it from growing larger, it also for a certain period prevents, or at least reduces very much, the formation of a coherent solid mass or shell in the casting. The condition of friability produced in this way in a certain period during freezing is the one responsible for certain defects found in castings, the most important of which is hot tears.[3]

A component which is often separated from the mixture during freezing is gas which was dissolved in the liquid state. It can appear as round bubbles or cavities shaped according to the intercrystalline gaps from which it displaces liquid metal.

SHRINKAGE IN CASTINGS

Equipped with this information on the way a metal solidifies, one now tries to find out what is likely to happen to a metal body freezing in a mould.

Temperature Distribution

Obviously, the first thing to be ascertained is the speed and direction of cooling. There have been some

FIG. 5.—EFFECT OF ARTIFICIALLY INTRODUCED NUCLEI.
Ingot about 1¼ natural size.
Effect of Ti addition on the grain size of an ingot of RR.50 aluminium-alloy (1.5 per cent. Cu, 12 per cent. Mg, 2.5 per cent. Si, 1.0 per cent. Fe, 0.9 per cent. Ni) : (Left) < 0.01 per cent. Ti; (Right) 0.17 per cent. Ti.

Solidification of Metals

theoretical calculations as well as actual measurements on this subject, mostly in very simple shapes as cylindrical billets used for extrusion or forging.[4 5]

The results of this work are roughly as follows (Fig. 7):—Very soon after freezing starts, the liquid area in the central part of the casting is uniformly at, or slightly above, the temperature of beginning of solidification. This is due to the latent heat of freezing which stands as kind of heat barrier between the liquid and the solid metal. According to the intensity of the cooling effect of the mould walls, the temperature drops more or less steeply as we pass through the frozen shell from the liquid metal toward the mould wall. In thick metal sections freezing in a sand mould, the temperature drop is very small, and freezing proceeds almost uniformly over the whole cross-section of the casting. On the other hand, in thick-walled metal moulds or water-cooled moulds there is a solid shell and the temperature gradient in it is considerable, of the order of, say, 100 deg. C. The time required to freeze the whole cross-section is about one-tenth of that of a sand mould.

The cooling conditions are of course also dependent on the thickness of the casting. In thin sections cast in a metal mould one can expect even higher temperature gradients, perhaps also penetrating into the liquid to a small extent. Thin sand-cast sections might be cooled almost as intensely as the 6-in. diameter billet in a cast-iron mould. On the other hand, the interior of very thick billets, say 2 ft. in diameter, cast in metal moulds might freeze under conditions not too far from those occurring in the 6-in billet cast in sand.

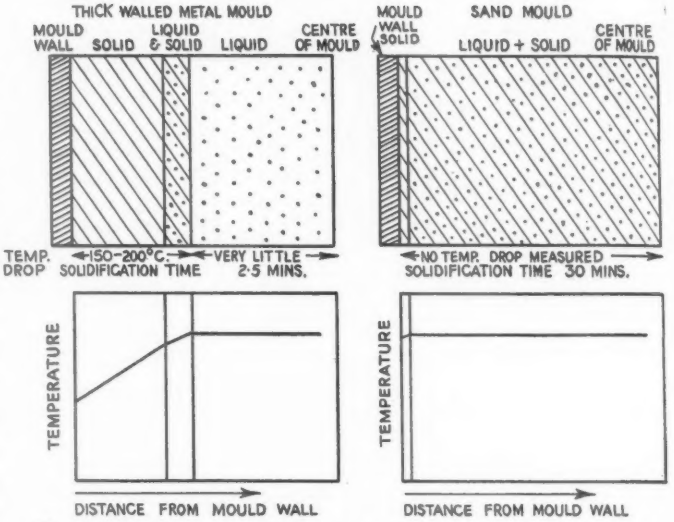

FIG. 7.—TEMPERATURE DISTRIBUTION AND PROGRESS OF SOLIDIFICATION IN A (BRASS 70/30) CYLINDRICAL BILLET 6 IN. DIAMETER, SHOWN DIAGRAMMATICALLY (DERIVED FROM ROTH'S WORK).

The upper diagrams show the distribution of solid and liquid metal in the zone between mould wall (left) and centre of billet (right). The lower diagrams show the corresponding temperature distribution along a radius of the mould.

FIG. 6.—A SERIES OF AL-SI ALLOYS, SHOWS THE EFFECT OF SEPARATION OF COMPONENTS DURING FREEZING. (*a*) WITHOUT SI, IS STRUCTURELESS; (*b*) 4 PER CENT. SI; (*c*) 8 PER CENT. SI.

The silicon (dark) which was uniformly distributed in the liquid metal is removed to the interstices of the (white) aluminium crystals. With increasing Si content the aluminium crystals become more finely ramified (from Sachs & Van Horn, Pract. Metallurgy).

(To be continued.)

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3 D. C G. Lees. *J. Inst. Met.* (1946) 72. p. 343–364.
4 W. Roth Diss. Aachen 1930.
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ON TUESDAY, the new foundry of the Wear Winch & Foundry Company, Limited, of Sunderland, was formally opened. The concern is now capable of making 600 tons of castings monthly, each weighing up to 25 tons. The area of the foundry is 29,000 sq. ft.

THE WELSH INDUSTRIES FAIR, organised by the National Industrial Council of Wales and Monmouthshire, opened at the Drill Hall, Cardiff, on Monday last. Quite a number of comparative newcomers to the principality are amongst the list of about fifty exhibitors representing every branch of industry. The Exhibition is open daily from 12 noon to 8 p.m. and closes on September 11.

Exchange Paper from the "Association Technique de Fonderie"

The Maurer Diagram and its Evolution and A New Structural Diagram for Cast Iron*

A Review of Constitutional Diagrams for Cast Iron

By H. Laplanche, Docteur ès Sciences, Ingénieur-Métallurgiste

(*Continued from page* 230.)

The Author has endeavoured to find out whether there is a function of the contents of T.C and of Si which is characteristic of this equal aptitude for graphitisation, or this equal stability of the cementite, in other words, whether there is an analytical expression, or an equation, common to all the curves of the same network, obtained with the same value of V, of such nature as to allow of passing from one curve to another by making a variation in one parameter of that equation.

To that end, he has first tried to isolate the carbide in cast irons of the various compositions under consideration, by attacking the metal either in a slow, prolonged manner, in hydrochloric acid or dilute sulphuric acid, or by cuprous ammonium chloride.[30] As the carbide is very little attacked whilst the ferrite is being dissolved, the carbides can be separated out by filtering and washing and their composition studied.

It thus appears that silicon (like all the alloying elements in steels) is soluble in iron, but that, in the presence of carbon; it associates with cementite in the form of iron-silicide Fe_2Si, so that everything behaves as if the pure cementite were replaced in the cast irons by a complex carbide $(Fe_3C)^x(Fe_2Si)^y$, a formula in which x and y, and consequently the centesimal composition, are functions of the contents of T.C and Si in the alloy.

However, contrary to what takes place in the case of complex iron and chrome carbides, or iron and tungsten carbides, etc., which are more stable than pure cementite, the silicon makes the carbide more unstable in proportion as the amount of silicon by weight is higher. The silicon content of this complex carbide thus appears as a measure of its intrinsic aptitude for dissociation into silicon-ferrite and graphite, and this, to the same degree, during solidification proper, as during the transformations to the solid state. Everything behaves, indeed, as if the complex carbide $(Fe_3C)^x(Fe_2Si)^y$ were first deposited in every case and then dissociated, or not, according to its chemical composition. The speed of this dissociation may be very great, so that dissociation follows immediately on deposition, and takes place spontaneously, as is the case with graphitic irons; or it may decrease down to zero, as is the case for completely white irons.[31]

Now, one can express the percentage content of complex carbide in the T.C and the Si, when the contents of T.C and Si in the alloy are known. It will be observed, indeed, that, by taking into account the atomic weights, Fe 56, C 12 and Si 28, one has numerically

$$Fe_3C = 180 = 12 \times 15 = 15\ C,$$

which can be interpreted in the sense that the weight of cementite is equal to 15 times the weight of the carbon it contains.

In the same way we have:—

$$Fe_2Si = 140 = 28 \times 5 = 5\ Si.$$

Thus the total weight of the complex carbide which is formed in 100 parts, by weight, of the alloy containing C_t per cent. T.C and Si_t per cent. Si is $15\ C_t + 5Si_t = 5(3C_t + Si_t)$ so that the centesimal contents of carbon and silicon in the complex carbide are

$$\gamma = \frac{C_t}{5\,(3C_t + Si_t)} \times 100$$

$$\sigma = \frac{Si_t}{5\,(3C_t + Si_t)} \times 100$$

It is this coefficient σ which characterises the aptitude towards dissociation of the carbide *from the liquid state to room temperature*, for a given law of cooling.

In a more precise manner, it has been verified experimentally, with sufficient accuracy, that, for the same law of cooling to room temperature, two alloys Fe-C-Si, containing the same proportion by weight of eutectic, and of which the carbides show respective contents σ_1 and σ_2 of silicon, give ratios of graphitic carbon over total carbon proportional to σ_1 and σ_2.

Moreover, let there be cast, in a constant manner, identical test pieces of various Fe-C-Si alloys. Let there be inserted in the mould a thermo-couple connected to a potentiometric recorder, with a high speed feed of the registering roll, so as to record at each second the temperature of the test bar. The experiment can be so organised that it is possible, at various temperatures, to remove a piece of the bar, to stop all transformation by quick quench and to analyse for the amount of graphite already formed. Then for each test bar examined, the curves temperature-time and temperature graphitisation are known.

*Presented to the London Conference of the Institute of British Foundrymen, June, 1948. Paper translated by R. W. Allott, M.A.

Structural Diagrams for Cast Iron

It is then discovered that alloys having the same value of σ show a ratio of graphitic carbon over total carbon proportional to the length of the effective stage of eutectic solidification before stoppage by quenching (or of the quasi-stage in the case of ternary alloys under consideration), that is to say, of the weight M of eutectic carbide formed to the moment of stopping by quenching. (It is known indeed that, other things being equal, the length of the eutectic stage of the curve temperature-time is proportional to the weight M of the eutectic formed, and that, moreover, the weight of *eutectic carbide* bears a constant relation with the total weight of eutectic, practically that of 1:2.)

To resume, for the same law of cooling, the aptitude towards graphitisation is proportional both to the content σ of Si in the carbide and to the weight M of the eutectic carbide. This aptitude is therefore proportional to the product $M \times \sigma$. Let this be called product K, which is necessarily proportional to the graphitic over total carbon, from what is stated above. This then gives $K = M \times \sigma \ldots$ (i).

An attempt will now be made to evaluate M as a function of the contents C_t and Si_t in T.C. and in Si.

In 100 parts by weight of the alloy there are $(15C_t + 5Si_t)$ parts of total carbides and consequently $100-(15C_t + 5Si_t)$ parts of iron. In the γ state, this iron is found in the form of a solid saturated solution.

Now it is established experimentally that the solubility of silicious cementite in γ iron is the same as that of pure cementite Fe_3C. The solid saturated solution contains in both cases 25 per cent. of its weight in soluble carbide and 75 per cent. of iron, which shows that the weight of soluble carbon is one-third of the weight of corresponding iron.

Therefore in 100 parts by weight of total alloy there are $\frac{100-(15C_t + 5Si_t)}{3}$ parts of soluble carbide.

It follows from this that the weight M of eutectic carbide, which is the difference between the total weight of the carbides and the weight of the soluble carbide, is equal to

$$M = 15\,C_t + 5\,Si_t - \frac{100-(15\,C_t + 5\,Si_t)}{3}$$

$$M = \frac{60\,C_t + 20\,Si_t - 100}{3} = \frac{20\,(3\,C_t + Si_t - 5)}{3}$$

The equation (1) then becomes :—

$$K = M \times \sigma = \frac{Si_t}{5\,(3\,C_t + Si_t)} \times \frac{20\,(3\,C_t + Si_t - 5)}{3}$$

$$K = \frac{4\,Si_t}{3}\left(1 - \frac{5}{3\,C_t + Si_t}\right) \quad \ldots\ldots\ldots\ldots \quad (2)$$

It follows from this that all the values of C_t and Si_t which, associated, give to the parameter K a given value, characterise the series of cast irons, which have the same tendency towards graphitisation, down to shop temperature, and which consequently have the same final structure for the law of cooling. If there be given a value for K, *e.g.*, K = 2, one can trace the corresponding curve by plotting C_t as ordinates and Si_t as abscissæ. This curve is traced by exact points, which it is then only necessary to join up.

By giving K successive values of 0.2, 0.5, 1, 2, 3, 4, etc., one obtains the network of curves on Fig. 24. Conversely one can determine the values of K which correspond to observed structures, and, particularly, determine experimentally those which correspond to the limits of the various structural zones, for a given section of the test-pieces. In this way, for cylindrical test bars 50 mm. diameter cast in green sand, the limits of the various structural zones are established generally as follows:—

Limit between white irons and mottled irons $K \leqslant 0{\cdot}80$
Limit between mottled and pearlite matrix irons $K \leqslant 1$
Limit between wholly pearlitic and wholly ferritic $K \leqslant 2$
Limit between pearlitic-ferritic and wholly ferritic $K \leqslant 3$

The analogy between the curves on Fig. 24 and the experimental curves of Uhlitzsch and Weicheldt is striking. In the two diagrams the curves are divergent towards increasing T.C. contents and convergent towards increasing silicon contents.

It should be noted here that the curves K = 1, K = 2, K = 3, etc., are fixed. What varies, when the speed of cooling of the alloy is changed is the position of the limiting curves of the various zones by relation to these fixed curves. For instance, if the diameter of the test-pieces be reduced, all the limiting curves of the zones are shifted towards the right. With a sufficiently high rate of cooling, a cast iron with the index K = 1.2 can give an entirely white structure. With separately cast test bars poured in green sand with a diameter of 10 mm., the values of K which

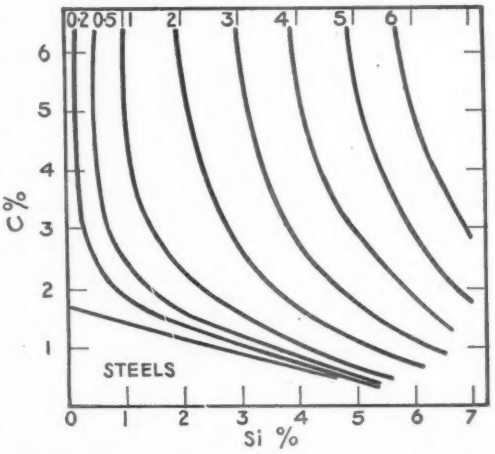


FIG. 24.—CURVES OBTAINED BY ASSIGNING ARBITRARY VALUES FOR THE PRODUCT OF THE SILICON IN THE CARBIDE AND THE WEIGHT OF THE EUTECTIC CARBIDE.

TABLE I.—*Numerical Results on a Series of Pure Irons.*

No.	Chemical composition.		Weight M of insoluble carbide (calculated).	G.C.	G.C. / T.C.	$K = \frac{M\sigma}{100}$	$\gamma = \frac{GC:K}{TC.}$
	Carbon.	Silicon.					
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
1	2.25	1.80	23.6	0·00	0·00	0.99	—
2	2.80	1.92	35.4	1.60	0.575	1.32	0.43
3	3.35	2.30	49.0	2.88	0.860	1.82	0.47
4	3.64	2.50	56.1	3.45	0.956	2.09	0.45
5	3.80	2.61	60.0	3.80	1.0	2.23	0.44
6	4.05	2.77	66.1	4.05	1.0	2.46	0.40

correspond to the respective four curves showing the limits already indicated are approximately

$$K = 1.2,\ K = 1.7,\ K = 2.3,\ K = 4.$$

In a general way the value of the ratio graphitic carbon over total carbon is practically proportional to K, after total cooling, for cast irons which are neither completely white nor wholly ferritic.

White irons do not follow the law of proportionality of the ratio graphitic carbon over total carbon, nor of the content σ of silicon in the carbide. For each rate of cooling there is a critical value σ_B such that all cast irons poorer in silicon give

$$\frac{\text{Graphitic carbon}}{\text{Total Carbon}} = 0$$

Similarly, as regards the ferritic cast irons, there is a critical value σ_F such that all cast irons richer in silicon give the figure

$$\frac{\text{Graphitic carbon}}{\text{Total Carbon}} = 1$$

The alloys which follow the law of proportionality $GC:TC = \lambda K$ vary therefore between two extremes σ_B and σ_F, which correspond respectively to the production of an entirely white iron or of an iron with a wholly ferritic matrix. The same remark can be made for the weight M of insoluble carbide. For each value of V there are two limiting values M_B and M_F, outside of which the value of the ratio GC:TC is no longer proportional to M.

To sum up, if λ be a coefficient varying with the mean speed of cooling, the expression

$$\frac{\text{Graphitic carbon}}{\text{Total carbon}} = \lambda K$$

applies to all cast irons which contain at the same time graphite and pearlite (mottled, pearlitic, pearlitic-ferritic cast iron).

As examples there will be found in Table I some numerical results obtained on samples of irons of various compositions, but chosen in such a way that

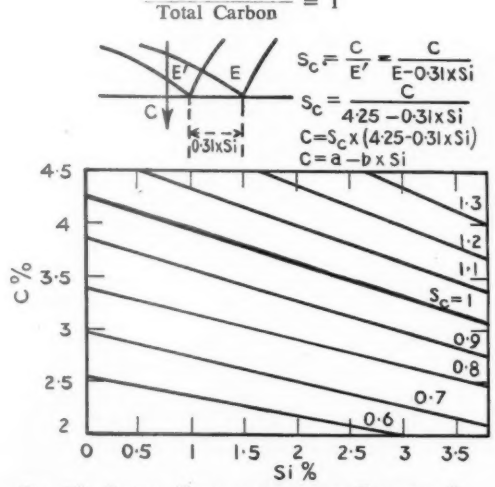


FIG. 25.—LINEAR EXPRESSION OF THE RELATION S_C FOR VALUES OF SILICON AND CARBON.

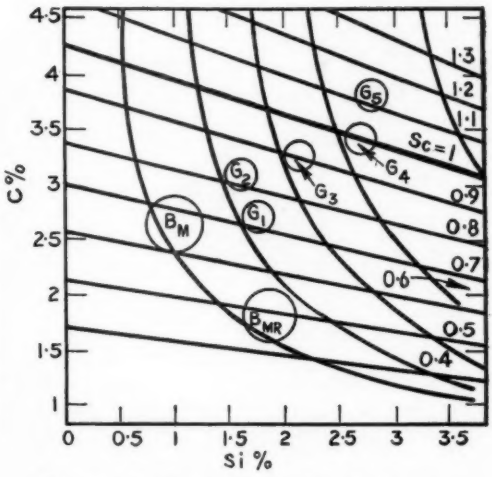


FIG. 26.—CURVES OF THE TYPE FIG. 24 SUPERPOSED UPON THE LINEAR RELATIONS OF FIG. 25.

Structural Diagrams for Cast Iron

the calculated content of silicon carbide was in every case in the region of 4 per cent. These results refer to cast irons prepared synthetically with very low contents of P, S, and Mn.

It will be seen that, for cast irons Nos. 2, 3, 4, and 5, containing both pearlite and graphite, λ is practically constant ($\lambda = 0.43$ to 0.47).

The limits in this case are

$$M_B = 24 \text{ and } M_F = 60.$$

Rectilinear System Indicating the Position of a Cast Iron by Reference to its Eutectic

There is another system by reference to which an alloy Fe-C-Si can be picked out on a diagram with two co-ordinates, carbon content and silicon content. It is known indeed that, in the absence of silicon, the carbon content of the eutectic alloy is 4.23 per cent. and that the limit of solubility of the carbon in the gamma iron is then 1.70 per cent., that is to say, practically four-tenths of the eutectic content.

But the presence of silicon lowers these two contents. To study its influence on the thermal diagram Fe-Fe_3C. the most exact method consists of studying the intersections of the spatial ternary diagram Fe-C-Si with the figurative planes of the silicon contents under consideration. All writers seem to be agreed on the following result. Each unit per cent. of silicon shifts the carbon content 0.31 per cent. towards the left (that is, the C in the eutectic), which thus becomes

$$E' = 4.23 - 0.31 \times \text{Si per cent.}$$

It is usual to call those alloys of Fe-C-Si hypo-eutectic, which have a carbon content lower than the content E′ of the eutectic, which corresponds to their content of silicon. On the contrary, those alloys are called hyper-eutectic, in which the carbon content is greater than E′.

If, therefore, the index of position be defined for an alloy Fe-C-Si in relation to the eutectic by the ratio

$$S_c = \frac{C_t}{4.23 - 0.31 \times Si_t} = \frac{C_t}{E_t}$$

where C_t and Si_t are the carbon and silicon contents of this alloy, such as they are shown to be by analysis, it is clear that the numerical value of this index allows of a classification of cast irons by reference to the eutectic E′.

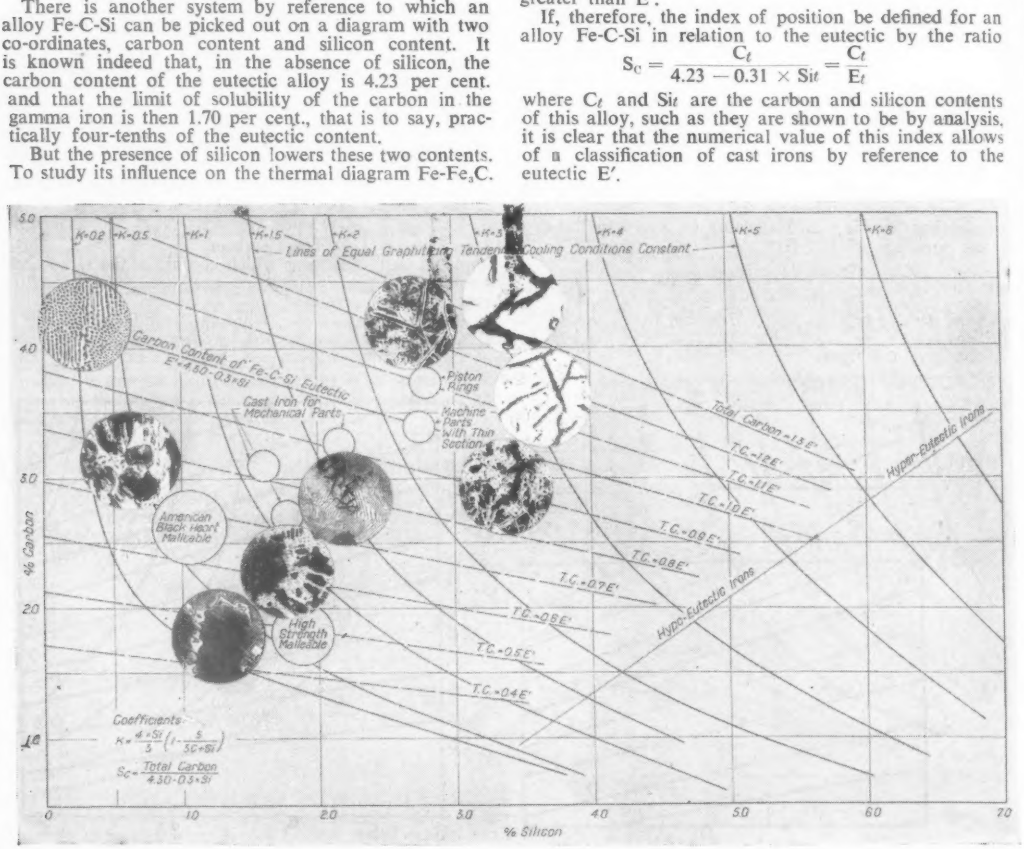


FIG. 27.—LAPLANCHE'S STRUCTURAL DIAGRAM FOR CAST IRON.

Indeed, by definition one has:—

$S_c < 1$ for hypo-eutectic irons.
$S_c = 1$ for eutectic irons.
$S_c > 1$ for hyper-eutectic irons.

In the presence of phosphorus, the value of S_c becomes, with a sufficient approximation:—

$$S_c = \frac{C_t}{4.23 - 0.31\,(Si_t + P_t)}$$

The expression of S_c shows that the contents of total carbon and of silicon are related linearly for each value assigned to S_c. Straight lines can then be drawn

$S_c = 1$; 0.9; 0.8; 0.7; 0.6; etc.

then

$S_c = 1.1$; 1.2; 1.3; .4; 1.5; etc. (Fig. 25).

It is known that the co-efficient S_c is related to the morphology of graphite (if one ignores the case of undercooling). In particular the hyper-eutectic irons show a primary graphite much coarser than that formed in the eutectic cells. In the case of heavy sections, the hyper-eutectic (large flakes visible in Fig. 2 (*a*)) produce "large-grain fractures." This is sometimes called kish, since it rises to the surface of the bath at the commencement of solidification.

Superposition of the Two Systems S and K

The two systems of Figs. 24 and 25 can obviously be superposed, since they relate to the same co-ordinates. Every cast iron is then found at the intersection of a curve $\frac{G.C}{T.C} = \lambda\ K$ with a straight line S_c (Fig. 26). The straight line S gives the position of a cast iron in relation to the eutectic. The curve λ K gives the structure of the matrix for a given value of V. It consequently gives the appearance of the fracture, white, mottled, grey or black.

A cast iron is therefore completely defined by the values of λ K and S_c for a given law of cooling. The determination of the contents of T.C. and Si, which are suitable for a given purpose, comes down then to choosing suitable values of K and S_c (K depending on V) and then to solve the equation

$$\frac{4\,Si}{3}\left(1 - \frac{5}{3C + Si}\right) = K$$

$$\frac{C}{4.25 - 0.31\,Si} = S_c$$

In practice, it is sufficient to place the typical structures on the ensemble of the two superimposed diagrams for each law of cooling. Thus, in Fig. 26 is shown, for 50 mm. sand cast test-bars, the position of various cast irons in general use in the foundry.

B_M—normal white iron for blackheart malleable.

B_{MR}—white iron for quick annealing for high strength malleable.

G_1, G_2, G_3—various engineering irons.

G_4—cast iron for piston rings (multi-cast).

Fig. 27 shows also several structures placed on the diagram for unit test-bars 50 mm. diameter.[16]

Conclusions

In what precedes, there has only been covered, in principle, the Fe-C-Si alloys, and it is essential to add a few observations:—

(1) Pure synthetic alloys, cooled in vacuo from the liquid state, always suffer a considerable undercooling, which has the effect of producing a punctiform graphite structure on an entirely ferritic matrix (Fig. 2 (*c*)) whatever may be the chemical composition. In a general way, Fe-C-Si cast irons do not give structures conforming to what might be expected from a diagram such as that in Fig. 27, by the extent to which they are subjected to undercooling during solidification.

(2) Sulphur has an effect opposite to that of silicon, that is to say, it stabilises the complex carbide, and its action is very definite. Even a content as low as 0.02 per cent. sulphur prevents a ferritic matrix being obtained with alloys Fe-C-Si-S. In the usual run of irons, sulphur is neutralised by manganese in the form of MnS.

(3) Phosphorus increases both S_c and K (for the same value of V). Moreover, it determines the formation of the eutectic system Fe-Fe_3C-Fe_3P, visible in Fig. 10 (Steadite or Phosphide Eutectic).

(4) All the elements stabilising the carbides (sulphur, chromium, tungsten, molybdenum, etc.) shift, to the right, the limits of the structure zones, other things being equal, of course. They act, therefore, in the same way as an increase in the mean speed of cooling.

(5) Hyper-eutectic cast irons have a graphite distribution corresponding to that of Fig. 2 (*a*). In hypo-eutectic irons the graphite has the appearance shown in Fig. 2 (*b*). Each cluster of graphite corresponds to a eutectic cell.[31, 32]

REFERENCES.

30 Revue de Metallurgie, No. 1, 1904, p. 52.

31 H. Laplanche, The mechanism of the solidification of hypo-eutectic grey irons, lecture to Assoc. tech. de Fonderie, Feb. 22, 1946.

32 A. Portevin and H. Laplanche, On the structure of the eutectic of grey cast irons, Revue de Metallurgie, Nos. 5 and 6, May-June, 1946, pp. 129-131.

DISCUSSION*

DR. ANGUS said it was an important Paper, if only for the fact that the Author had collected much of the evidence that had been put forward in previous years in an attempt to make a diagram that made sense of the cast-iron structure. He thought many foundrymen had now reached the point of view that "to the making of diagrams there was no end." The Maurer diagram had had greater accuracy attributed to it than was claimed by Dr. Maurer himself, merely because the original Paper had not been read. The original diagram, however, had established that there was an area over which one could get a pearlitic iron for a fairly wide range of section sizes and for this very valuable indication the credit should go to Dr. Maurer. The remainder of the diagram, however, as Dr. Laplanche had shown, had little practical value.

Influence of Phosphorus

The thing that interested him was the way that all makers of diagrams agreed to disregard

*At the London Conference this Paper was presented in summary form by Dr. A. B. Everest on behalf of the Author.

Structural Diagrams of Cast Iron

the effect of phosphorus, and that, he thought, was a fundamental error. They had, admittedly, in many cases confined themselves strictly to low phosphoric irons, but from a foundryman's point of view that was such a severe limitation that such diagrams became of academic rather than practical interest. The important thing about phosphorus that was sometimes forgotten was that it affected the amount of graphite in the eutectic to about the same extent that silicon did. If phosphorus were put into a given cast iron, it did not merely exist as a separate phase, but it also altered the amount of graphite present, and graphite itself was also a graphitising agent just as silicon was. Therefore, from the practical foundryman's point of view, a diagram which excluded phosphorus was of academic use only. It was all the more remarkable that Dr. Laplanche on page 15 of the Preprint quoted the value for carbon saturation, which included the effect of phosphorus and in the next sentence he went on to state that the expression of the S_c value (the carbon saturation value) showed that the content of total carbon and silicon was related linearly to each value associated with S_c. That was only true where the phosphorus was fixed, and it was not true for a wide range of composition. He thought the diagram showed by Dr. Laplanche was an extremely interesting one and seemed to be quite accurate, providing one did work entirely with low phosphorus irons. But if the effect of phosphorus were to be included, then something different had to be done.

Diagram of Skipp

No reference to the diagram put forward by Skipp had been made. This diagram attempted to correlate structure with section size and carbon saturation value. The Skipp diagram was not a theoretical diagram, but was based on experimental data with low phosphorus irons, but if one made the necessary corrections for phosphorus, it was surprisingly accurate and the likely structure of a casting could be predicted from the section size and the carbon saturation value. That was something which had not been so satisfactorily done by any previous diagram. With all diagrams it was important to realise they were only approximations, and the lines separating the different areas were really the centre lines of bands of uncertainty. If one did not read into them more than was intended, then they could be very valuable

Equivalent Sections

The only other point he would like to raise was that the Author had accepted the view that the cooling rate of a cylindrical bar was the equivalent of a flat section half the diameter of the bar. That was an accurate theoretical assumption for the centre sections of long bars and large plates which was rarely used in this country and might well be more frequently employed. It was based on the volume-area relationship, and up to about 2½ in. in diameter it was fairly satisfactory. Above 2½ in. it was not so accurate as a 4-in. dia. bar actually cooled very much more slowly than would be anticipated from its volume-area relationship.

In conclusion he said he could only admire the extremely able way in which, in the absence of Dr. Laplanche, Dr. A. B. Everest had summarised the Paper. He thought Dr. Laplanche had done them all a service by showing them the actual basis of the Maurer diagram and the weaknesses attached to it, and they were indebted to him and to Dr. Everest for the able way in which the Paper had been put forward.

The CHAIRMAN (Mr. A. E. Peace), closing the discussion, said he was sorry to have to do so, but their time limit had already been exceeded. He was sure they would wish him to express their thanks to Dr. Laplanche for the Paper, and to Dr. Angus for his comments; their thanks also were due to the French Foundry Association for sending that Paper.

British Standards Institution

One and a Half per Cent. Manganese Steel Castings

B.S.1456 for 1½ per cent. manganese steel castings for general engineering purposes has recently been issued. Two grades of castings, P and R, are specified according to the ultimate tensile stress obtained from the test-piece. The chemical composition of the steel is specified and test requirements relate to the tensile and impact tests. Provision is also made for non-destructive tests and hardness test after heat-treatment where required. Details are included of process of manufacture, fettling and dressing, freedom from defects, provision of test samples, testing facilities, branding and repairs to castings. Appendix A gives recommendations with regard to welding procedure. Copies of this standard can be obtained from the British Standards Institution, Sales Department, 24, Victoria Street, London, S.W.1, at a cost of 2s., post free.

Publication Received

An Epitome of the Building up of a Rhodesian Firm, 1894-1948. Published for private circulation by F. Issel & Son, Limited, Khami Road, Bulawayo, Southern Rhodesia.

In this 24-page brochure is told the story of an adventurous Netherlands-born engineer, who successfully pioneered the building up of an engineering and foundry business in Bulawayo. This man, Mr. F. G. M. Issels, after training at the Middlesbrough works of Bolckow Vaughan, left for Natal in 1891. In May, 1894, he set out in an ox wagon for Matabeleland, arriving in Bulawayo in October. Showing much ingenuity in improvisation, he patiently built up the premier engineering concern in the city. Now the Firth Brown group of companies have associated themselves with the founder's son, Mr. Henry G. Issels, B.Sc. (Eng.), M.I.Mech.E., in the conduct of the enterprise, which is now housed in a factory to the west of the city. The brochure is a fitting, if slightly belated, commemoration of fifty years of work, adventurously started and well continued.

Simple Time Standards for the Foundry

By J. Rodger

The following scheme is specially suitable for a foundry in a general engineering works, and can also be applied to a jobbing foundry. The advantage of the scheme to be outlined is that it can be operated as an individual bonus system, without the services of a rate-fixer. A girl can fix the time allowed, given the weight of the casting. Also, any agreed national increases or other adjustments required to the scheme are simply made by adding or subtracting a percentage to seven basic rates at x hours per cwt.

Weight Groups as a Basis

The essence of the scheme is that a fixed rate in hours per cwt. is assessed for different weight groups of heavier castings. This is much more accurate than paying bonus on a straight tonnage basis. Following is a list of weight groups with their appropriate hours per cwt. which have been compiled for a programme of general engineering castings, but, of course, the basic standard times for a particular organisation will depend on the intricacy or otherwise of the general run of castings, and also on the range of weights of castings made. For instance, if a foundry never makes a casting over 2 cwts., then the weight groups would require to be split up differently to give about seven groups between 1 lb. and 224 lb.

Weight of casting.	*Proposed basic hours per cwt. figure for bonus.*
0–14 lb.	9 hours per cwt.
15 lb. to 1 cwt.	6 ,, ,,
1 cwt. 1 lb. to 2 cwt.	4½ ,, ,,
2 cwt. 1 lb. to 5 cwt.	4 ,, ,,
5 cwt. 1 lb. to 10 cwt.	3 ,, ,,
10 cwt. 1 lb. to 20 cwt.	2½ ,, ,,
20 cwt. 1 lb. upwards	2 ,, ,,

To arrive at these basic time standards, the weight groups should first be fixed, then from past cost records should be listed a number of representative total times taken against the total weight of the castings, in each particular weight group. An average may then be struck by dividing the total weight in cwt. by the total hours, in each group. If preferred, the answer can be recorded in minutes per lb. instead of hours per cwt. Naturally, the more past records used for striking the average, the more accurate the average will be.

It may be that accurate past records are not available; in that case it would be necessary to record times taken and weights of castings produced for a week or two until a sufficient number of records of times taken at ordinary rates were accumulated to allow an average to be struck.

Adjustments

Although the basic hours per cwt. is arrived at from past records in the first instance, once the scheme is working, adjustments can be made by arrangement to suit altered conditions. For instance, a section of the foundry may become mechanised, but only affecting one or two weight groups. The weight groups involved would then have their rates reviewed accordingly. On the other hand, a National rate increase would affect all weight groups.

Method of Payment

Once the basic figures are ascertained, it will be seen that the hours per cwt. decrease as the weight increases. These basic figures can be applied as the allowed time for castings, either separately or in the group. The allowed time for each casting referred to, of course, is the actual time to be paid for, irrespective of how long the man takes, and can be resolved into a piece-work price if required. In taking past performance averages as standard times, one expects a saving in time of 27½ per cent. over these past performances, since there is an obligatory 27½ per cent. to be earned on basic wage rate. In other words, if working a 44-hr. week, the total allowed time for all work done by one man should be a minimum of 44 plus 27½ per cent. of 44, or 56 hrs. Whether the basic hours per cwt. is actually given at the past performance figure or adjusted up or down, depends on the *tempo* of the workers in the moulding shop when on straight time rates.

In a shop where the rate of working is very slow on straight time rates, the allowed hours would not even be that of past performance averages, but, say, 10 per cent. less. Alternatively, if the working of the shop is faster than is usually found on straight time rates, then the past performance average hours would be increased by a suitable percentage to allow 27½ per cent. to be earned without undue fatigue.

Group Bonus

As a group bonus, all the castings for the week would be added up for each weight group, and the total hours allowed would be that total weight multiplied by its basic hours per cwt. Thus, apart from grouping castings by weight and finding total weights, seven simple multiplication sums have to be worked out to arrive at the total allowed hours for the week's work for the department.

For general engineering castings, the essence of the scheme is a more accurate assessment than one on a purely tonnage basis, but simplicity nevertheless is achieved by the taking of a little of the "rough" with the "smooth." On jobbing work, where there may be a large variety of different kinds of castings, the exceptions can sometimes be grouped separately from the standard scheme. For instance, heavily cored intricate castings for small oil engines may be assessed at a special rate of 6 hrs. per cwt. for the 5- to 10-cwt. weight range. These are outside the general run of work, but are encountered as exceptions at the Author's foundry. Very rarely does one find a casting which is so simple or solid that it becomes necessary to reduce the basic hours, as, from a psychological point of view, any slight gain would be offset by loss in confidence in the scheme. In addition to operating a bonus system, standard times would be useful to estimators or for budgetary control.

Imports and Exports of Iron and Steel

The following tables, based on Board of Trade returns, give figures of imports and exports of iron and steel in July, and the first seven months of 1948. Figures for the corresponding period of 1938 are given for purposes of comparison.

Total Exports of Iron and Steel.

Destination.	July, 1948.	Seven months ended July.	Seven-twelfths of 1938.
	Tons.	Tons.	Tons.
Eire	6,937	43,201	32,503
Channel Islands	817	5,687	4,326
Gibraltar	419	2,021	515
Malta and Gozo	699	2,629	1,344
Cyprus	388	2,505	966
Palestine	769	11,608	4,708
British West Africa	3,544	28,121	29,017
Union of South Africa	16,565	86,884	134,801
Northern Rhodesia	1,997	5,912	12,002
Southern Rhodesia	4,923	13,700	21,124
British East Africa	6,851	40,258	15,127
Bahrein, Koweit, Qatar and Trucial Oman	2,616	18,711	*
India, Pakistan, etc.	7,536	47,651	92,562
British Malaya	3,801	16,141	38,841
Ceylon	1,757	6,716	15,185
North Borneo	1,698	8,445	66
Hong Kong	4,658	19,876	13,764
Australia	5,925	43,285	99,694
New Zealand	4,610	35,364	76,932
Canada	4,062	14,085	49,822
British West Indies	6,462	19,980	25,813
British Guiana	441	2,934	1,747
Anglo-Egyptian Sudan	755	5,849	4,836
Other British countries	1,818	10,015	8,152
Russia	—	13,119	2,537
Finland	7,271	43,682	10,271
Sweden	8,490	60,118	6,985
Norway	6,179	34,580	11,826
Iceland	341	2,759	384
Denmark	9,369	45,662	50,899
Poland	481	1,250	1,451
Netherlands	7,277	51,328	30,076
Belgium	829	6,973	11,856
France	2,764	9,419	7,809
Switzerland	1,865	11,484	1,623
Portugal	1,498	15,820	4,499
Spain	912	3,843	4,529
Italy	102	2,423	2,998
Hungary	304	591	19
Czechoslovakia	30	225	1,350
Greece	337	2,143	1,022
Turkey	2,102	11,126	8,025
Dutch East Indies	2,132	13,462	15,929
Dutch West India Islands	410	4,880	1,437
Belgian Congo	13	680	177
Algeria	22	353	30
Portuguese East Africa	381	1,513	8,295
Syria	722	2,314	1,520
Lebanon	2,998	6,306	
Egypt	3,705	28,863	20,072
Iraq	3,732	31,347	15,015
Iran	6,744	64,766	64,388
Burma	3,113	19,215	10,799
Siam (Thailand)	369	2,084	3,498
China	1,235	12,024	13,131
U.S.A.	199	1,234	1,276
Cuba	48	1,635	421
Colombia	404	4,358	2,230
Venezuela	5,108	30,842	2,727
Ecuador	183	1,628	929
Peru	92	2,189	1,769
Chile	1,860	6,863	3,671
Brazil	1,940	11,022	9,911
Uruguay	629	5,535	4,426
Argentine	16,539	55,222	46,291
Other foreign countries	1,628	17,426	47,646
Total	194,405	1,131,884	1,117,594

* Included in "Other British countries" and "Other foreign countries."

Total Exports of Iron and Steel.

From	July, 1948.	Seven months ended July.	Seven-twelfths of 1938.
	Tons.	Tons.	Tons.
Australia	1,637	11,582	21
Canada	6,535	47,408	68,469
Other British countries	361	3,083	94,052
Sweden	1,477	9,613	52,381
Norway	3,153	17,401	19,702
Germany	300	1,925	56,000
Belgium	12,980	67,535	159,647
Luxemburg	2,562	5,648	34,184
U.S.A.	8,535	74,478	117,070
Other foreign countries	9,059	27,293	182,639
Total	46,599	265,966	784,157
Iron ore and concentrates—			
Manganiferous	9,353	13,853	36,332
Other sorts	927,143	5,197,164	2,976,091
Iron and steel scrap and waste, fit only for the recovery of metal	95,329	372,222	368,785

Exports of Iron and Steel by Products

Product.	July, 1948.	Seven months ended July.	Seven-twelfths of 1938.
	Tons.	Tons.	Tons.
Pig-iron	153	545	54,799
Ferro-alloys, etc.—			
Ferro-tungsten	114	532	301
Spiegeleisen, ferro-manganese	56	2,437	3,031
All other descriptions*	44	410	611
Ingots, blooms, billets and slabs	168	3,065	5,684
Iron bars and rods	736	3,523	1,865
Sheet and tinplate bars, wire rods	214	2,357	9,077
Bright-steel bars	2,026	14,010	3,843
Other steel bars and rods	10,869	64,622	59,503
Special steel	1,481	11,432	2,877
Angles, shapes and sections	9,331	51,751	39,010
Castings and forgings	569	3,674	944
Girders, beams, joists and pillars	2,214	12,663	19,525
Hoop and strip	3,527	21,805	21,803
Plates, ⅛ in. thick and over	11,254	71,564	76,395
Black plates	5,458	38,866	8,481
Black sheets	4,123	19,526	37,048
Galvanised sheets	9,140	44,847	85,712
Tinplates	14,895	112,747	186,266
Tinned sheets	472	2,818	823
Terneplates	—	118	2,523
Decorated tinplates	257	783	2,548
Other coated plates	331	2,234	131
Cast-iron pipes, up to 6-in. dia.	7,098	36,945	28,541
Do., over 6-in. dia.	6,954	33,553	25,062
Wrought-iron tubes	28,206	175,116	128,317
Radiators and central-heating boilers	308	2,020	2,350
Railway material	23,636	109,118	92,257
Wire	3,788	23,046	32,190
Cable and rope	3,131	16,564	9,567
Netting, fencing and mesh	1,504	10,215	5,493
Other wire manufactures	818	4,298	2,142
Nails, tacks, etc.	1,089	4,372	2,221
Rivets and washers	855	4,792	4,979
Wood screws	263	2,843	1,465
Bolts, nuts and metal screws	2,486	12,637	10 251
Stoves, grates, etc. (excl. gas)	1,293	7,271	4,086
Do., gas	323	1,781	1,252
Sanitary cisterns	166	905	1,640
Fencing material	489	2,135	2,993
Anchors, etc.	967	5,788	3,696
Chains, etc.	823	5,449	3,670
Springs	455	3,729	2,293
Hollow-ware	6,655	47,147	6,244
All other manufactures	25,666	135,831	124,085
Total	194,405	1,131,884	1,117,594

* The figures for 1938 are not completely comparable with those for subsequent years.

Personal

MR. A. T. MAXWELL has been elected to the board of the Steel Company of Wales, Limited.

MR. E. BURGESS, technical director of Marshall, Sons & Company, Limited, engineers, boilermakers, etc., of Gainsborough, recently returned from a three-month business trip, which included visits to India, Australia and New Zealand.

MR. HUGH HENDERSON, commercial manager of the Appleby-Frodingham branch of the United Steel Companies, Limited, has been elected president of the Lincolnshire Iron and Steel Institute in succession to WING-COMM. J. B. R. BROOKE.

MR. WALTER H. BULPITT, managing director of Bulpitt & Sons, Limited, aluminium hollow-ware manufacturers. of Birmingham, was entertained at dinner by his co-directors recently to mark the occasion of his 70th birthday. Mr. Bulpitt has been a member of the firm for 55 years.

MR. F. N. KIRBY, assistant research mechanical engineer of C. A. Parsons & Company, Limited, engineers, etc., of Newcastle-upon-Tyne, has been awarded a Clayton Fellowship, valued at £350 per annum for two years, by the Institution of Mechanical Engineers. He will study developments on the gas turbine.

MR. H. E. WRIGHT, a director and general manager of the Steel, Peech & Tozer and the United Strip & Bar Mills branches of the United Steel Companies, Limited, has left for Canada. Mr. Wright will make a tour of the principal railway centres between Montreal and Vancouver and hopes to obtain further orders for steel supplies to the Canadian railways.

Wills

OKES-VOYSEY, MAJOR W. A., of the British Aluminium Company, Limited	£2,646
LAMBERT, HAROLD, late chairman of Hudswell, Clarke & Company, Limited, locomotive builders, of Leeds	£16,977
JOHNSON, PARKIN, founder of Parkin Johnson & Company, Limited, iron and steel merchants, of Sheffield	£24,178
LEWIS, D. R., works manager of Bayliss, Jones & Bayliss, Limited, iron and steel rollers, etc., of Wolverhampton	£8,124
SMITH, R. L. H., consulting metallurgist, of Hove, and for many years chief metallurgist of Vickers-Armstrongs, Limited	£18,086

Blast-furnace Output Record

A world's record pig-iron production is claimed by Jones & Laughlin Steel Corporation for its No. 3 furnace at the Aliquippa Works. Prior to shutting down for complete relining, the stack had produced 5,823,950 tons of iron. The furnace operated almost continuously for 14 years 11 months and two days. During the entire campaign the stack had no repairs other than a relining from the mantle to the furnace top in 1942. The stack is claimed to have established a monthly tonnage record by producing 48,505 tons, an average of 1,565 tons a day.

Morgan Crucible Company

New Subsidiary and Stock Division

"We are in the course of registering another company under the name of Morgan Refractories and are constructing a factory in Cheshire in which to house it," stated Mr. P. Lindsay, chairman, at the annual meeting of the Morgan Crucible Company, Limited.

In this factory they intended to promote large-scale production of a range of high-temperature refractories of recent conception. These should make a valuable contribution towards the solution of major problems now facing key industries by permitting furnaces to be operated at much higher temperatures, at more rapid production rates and reduced fuel consumption—three separate and distinct, or, alternatively, complementary objectives.

The refractories they had in view might play a part also in some of the outstanding present-day technical developments—such as atomic energy, gas turbines and certain new chemical engineering processes.

The board of the company has informed stockholders that it considers that the capital represented by "B" ordinary stock is greater than future employees and ex-employees will be able to hold when existing large stockholders have passed on. The directors therefore propose to divide the £1,600,000 of "B" ordinary stock into £800,000 "A" ordinary stock and £800,000 of "B" ordinary stock.

The alteration will raise the amount of authorised "A" ordinary stock to £1,550,000 out of a total authorised capital of £4,587,000.

Industrial Capacity of Ordnance Factories

The part played by the Ordnance factories in aiding the production and export drive is examined in the seventh report on the Parliamentary Select Committee on Estimates. The Committee recommends an immediate and complete review of industrial capacity of the factories. It is recorded that civil orders worth £22,000,000 have been accepted over the past two years by the 22 factories retained under direct Government control; about half of these orders came from Government departments. Work completed in 1946-47 was worth £4,710,889, while it is also pointed out that the average working rate in the factories is only 30 per cent.

The Committee states that, taken as a whole, civil work undertaken by the factories at present shows a loss. It adds that it is not in a position to determine how much, if any, of the loss is attributable to management of the factories.

FIRMS interested in openings for tractors and agricultural implements in Canada should forward illustrated literature, together with prices, to the Export Promotion Department, Thames House North, Millbank, London, S.W.1 (reference E.P.D. 3563/48), for transmission to the Trade Commissioner at Montreal.

News in Brief

THE PRICE of wolfram now ranges from 95s. to 105s. nominal per unit, c.i.f. European ports, compared with 100s. to 105s. previously.

PROFIT MARGINS have been reduced on a further list of goods in South Africa, including tractors, agricultural implements, machinery, and stoves.

THE MINISTRY OF SUPPLY has announced the following further interim allocations of tin metal for the second half of 1948:—Argentina, 100 tons; Italy, 1,200 tons, and Mexico, 50 tons.

LONG-SERVICE AWARDS have been made to 65 employees of Bayliss, Jones & Bayliss, Limited, iron and steel rollers, etc., of Wolverhampton, who, between them, have 2,380 years' service.

ON AUGUST 25, an Armstrong Siddeley Mamba propeller turbine aero engine completed a 500-hr. sealed endurance test. In the course of the run the compressor and turbine made 370 million revolutions.

THE BANK OF ENGLAND has sold at about 13s. 10½d. its remaining holding of about 310,000 6s. 8d. ordinary shares in Richard Thomas & Baldwins, Limited. The sale was made in one bargain involving about £200,000.

HUMPHREYS & GLASGOW, LIMITED, Carlisle Place, London, S.W.1, and Robert Dempster & Sons, Limited, Elland, Yorks, are to supply cast-iron pipes (£1,700) and grids for purifiers (£800), respectively, for Glasgow Corporation.

A DOCUMENTARY RECORDING was made by the B.B.C. recently of the tapping of an open-hearth furnace, the rolling of an ingot in a cogging mill and the handling of steel in a 24-in. mill at the Rotherham Works of the Park Gate Iron & Steel Company, Limited.

THE 800-TON STEAMER Kerryhead, badly damaged four years ago on the shores of France, has been bought by the British Iron & Steel Corporation, Limited, from a French salvage firm, and is to be broken up by Clayton & Davie, Limited, Dunston.

THE NORTHERN EMPLOYERS' BRASSFOUNDERS' ASSOCIATION, which was founded by the late Mr. George Gummer, who was president for 26 years and whose son, Mr. George Gummer, a director of Gummers, Limited, Rotherham, is the present president, will shortly celebrate its jubilee.

SPEAKING at the annual meeting of the Broken Hill Proprietary Company, Limited, in Sydney, Australia, on August 27, Mr. H. G. Darling (chairman) forecast a rise in Australian iron and steel prices. He said that Australian prices were still "pounds per ton" below those overseas, and there were no signs of an abatement in demand because of accumulated wartime orders, post-war industrial expansion and inability to operate production units near capacity through insufficient coal and labour. Shortage of coal and labour had meant a loss of 440,000 tons of steel ingots in the year ended May last, he added.

IN HIS STATEMENT accompanying the annual accounts, Mr. J. H. Jolly, chairman of Guest, Keen & Nettlefolds, Limited, states that it would be a national disaster if the State, with its cumbersome slow-moving and doctrinaire methods attempted to control by nationalisation that highly complex industry known as the iron and steel trade. Nationalisation of industry had not shown any greater efficiency, any lowering of prices, any improvement of quality or service, or contributed anything more to Britain's competitive power in export markets than when operating under private enterprise; rather the reverse.

Contracts Open

The dates given are the latest on which tenders will be accepted. The addresses are those from which forms of tender may be obtained.

Cairo, October 15—Supply and erection of a complete refuse treatment and fertiliser plant, for the Societe des Engrais Organiques. Export Promotion Department (Room 1086), Thames House North, Millbank, London, S.W.1.

Coalville, Leics, September 18—Supply of 222 heating stoves, for the U.D.C. The Engineer and Surveyor, Municipal Offices, Coalville.

Durban, South Africa, October 15—Switchgear, for the Durban Municipal Electricity Department. Export Promotion Department, Thames House North (Room 1073), Millbank, London, S.W.1. (Reference No. E.P.D. 39837/48.)

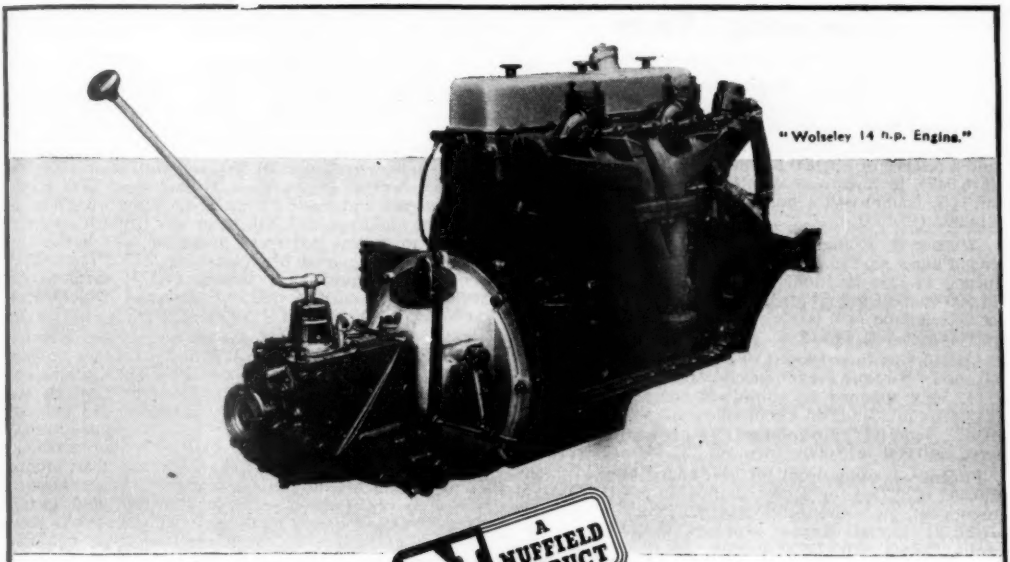
Pontypool, September 27—Construction of stoneware and concrete pipe sewers and 240 yds. of 21-in. spun-iron pipe sewers, etc., for Eastern Valleys (Monmouthshire) Joint Sewerage Board. John Taylor & Sons, engineers, Artillery House, Artillery Row, London, S.W.1. (Fee £5, returnable.)

Pretoria, South Africa, November 15—Transformers, for the Electricity Department. Export Promotion Department (Room 1073), Thames House North, Millbank, London, S.W.1. (Reference No. E.P.D. 39821/48.)

German Steel Scrap

Britain and the United States are seeking agreement on a price to be paid for steel-scrap imports from Germany. Government officials state that the United States believes $26 a ton is enough, whereas Britain wants to pay $30 to expedite delivery, according to a message from Washington.

Mr. Robert W. Wolcott, president of the Lukens Steel Company, who recently made a trip to Germany at the request of the U.S. Department of Commerce, said that if the United States was to obtain more scrap steel from Germany, steps must be taken to remove the present obstacles. He recommended that a purchasing and selling organisation be established to co-operate with Britain in matters concerning scrap to be exported from Germany and reported that there was enough scrap in Germany to support an export programme and supply the German steel industry.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Company News

(Figures for previous year in brackets.)

Central Provinces Manganese Company—Interim dividend of 7½%, less tax (7½%, tax free).

Newton Bros. (Derby)—Net profit for the year ended March 31, after providing for depreciation, taxation, and a reserve of £10,000 for stock contingencies, £21,780 (£16,047); to reserve account, £5,000 (£4,480); dividend of 7½% (same) and a bonus of 7½% (same); forward, £15,092 (£9,173).

Warner & Company—Trading profit for the year ended June 30, £15,279 (£17,626); income from investments, £1,123; taxation, £8,000 (£8,500); depreciation, £1,500 (same); net profit, £6,169 (£7,681); final dividend of 5%, making 7½% (same), plus a bonus of 5% (same); forward, £6,608 (£4,674).

United Gas Industries—Consolidated net profit, after taxation, for the year ended March 31, £192,984 (£152,560); retained by subsidiary companies, £28,345 (£13,176); dividends on the ordinary and deferred shares of 17% and 175% respectively (same); to general reserve, £50,000 (£25,000); forward, £32,544 (£29,121).

Fodens—Trading profit for year ended May 31, after £30,883 (£24,713) for depreciation, £121,584 (£123,405); investment, etc., revenue, £1,944 (£2,453); tax, £63,913 (£62,038); capital increase expenses, £1,015 (£88); net profit, £58,600 (£60,782); dividend of 10% (same); to general reserve, £35,000 (£40,000); forward, £23,239 (£20.884).

Wellman Smith Owen Engineering—Consolidated net profit for year ended March 31, £93,684 (£43,519); brought in, £64,239 (£55,283); general reserve, £50,000 (£10,000); special reserve for depreciation and obsolescence, £15,000 (£10,000); written off patent rights, £5,000; dividend of 12½% (same); forward, £70,918, of which £47,671 (£48,360) is retained by parent company.

Bromilow & Edwards—Trading profit for the year ended March 31, £44,536 (£26,920); depreciation, £5,197 (£6,562); taxation, £18,800 (£6,000); net profit, £15,676 (£10,246); reserves made in previous years not now required, £2,152 (nil); written off shares in subsidiary, £2,453 (nil); to general reserve, £6,000 (£2,500); dividend of 10% and bonus of 2½% (same); forward, £2,243 (£430).

Tungsten Manufacturing—Consolidated trading profit for year ended September 30, 1947, including £1,564 non-recurring item, £13,264; depreciation, £1,467; works development, £196; debenture interest, £454; debenture discount written off, £600; intercompany loan interest, £329; net profit, £6,605; brought in, £6,961; debts recovered from occupied countries, £1,222; tax not required, £685; to tax, £3,806; general reserve, £3,500; preference dividend, £626; balance, £7,541.

Newman & Watson—Consolidated profit for year ended March 31, £64,571; depreciation, £4,379; bank interest, £4,189; legal and special expenses, £1,180; written off preliminary expenses, £172; written off goodwill, £100; income-tax, £25,985; profits tax, £8,900; to outside shareholders, £217; to subsidiaries' balances, £2,520; to holding company's dividends, £5,981; general reserve, £7,000; to profit and loss, £3,365, making £8,729 forward; ordinary dividend of 7½% (6%).

Aluminium Castings Company—Consolidated trading profits to March 31, £97,119; interest, £165; to audit fees, £978; depreciation, £22,003 (£9,635); directors' fees and other emoluments, £8,700; interest. £5,228; profits tax, £11,379; income tax, £22,727 (taxation £45,477); net profit £26,269 (£38,251); provision for repairs not now required, £1,500; adjustment of taxation, £28,595; written off preliminary expenses, £74; goodwill, patents and trade marks, £53,506; appreciation in value of buildings, £45,000; from war damage account, £4,138; to capital reserve of profits of subsidiaries unappropriated at dates of acquisition, £37,207; to dividend on 6% preference shares, £4,575; dividend of 11¼% (15⅝%) on preferred ordinary, and 20% (32½%) on ordinary; forward, £31,659 (£32,835).

John Lysaght—Consolidated profit and loss account of company and its subsidiaries for 1947 shows trading profit, less losses, of the group, £793,139; surplus on realisation of stocks, £141,187; dividends and interest on trade investments, £276,600; dividends and interest on quoted investments, £6,347; miscellaneous income, £229; debenture interest, £119,870; depreciation £395,403; taxation, £416,307; net profit, £282,271; profits on realisation of quoted investments, £88,125; surplus provisions of previous years for taxation and maintenance, £89,575; withdrawn from reserves of subsidiaries, £115,948; balance transferred from consolidated profit and loss account, being the proportion of the group profits brought into the accounts of the holding company, £496 009; brought forward, £434,033; to general revenue reserve of John Lysaght, Limited, £200,000; preference dividend, less tax, £19,800; dividend of 15%, less tax, on the ordinary shares, £165,000; unappropriated profits carried to balance sheet, £545,242.

Guest, Keen & Nettlefolds—Consolidated profit and loss account for the year ended March 31 shows:—Trading profit, less losses, £6,101,839 (£4,465,294); dividends and interest on investments in subsidiaries (not consolidated): Guest, Keen Baldwins Iron & Steel, £251,426 (£251,743) and Swedish companies £140,821 (£140,796); dividends and interest on trade investments, £10,054 (£5,430); on quoted investments, £133,644 (£173,204); miscellaneous income, £20,289 (£27,516); debenture and fixed loan interest £167,106 (£171,595); depreciation and losses, less profits, on disposals of fixed assets, £9,190; taxation, £3,162,967 (£2,230,136); net profit, £1,793,216 (£1,579,248); profits on realisation of quoted investments, £238,281 (£137,200 transferred direct to revenue reserves); surplus taxation provisions of previous years, £113,136 (£594,912); income, less charges, not applicable to the year, £98,856 (£131,464); to outside shareholders' interests, £40,248 (£45,111); retained by subsidiaries, £278.968 (£402,192); balance to appropriation account of Guest, Keen & Nettlefolds, £1,924,273 (£1,858,321); to general revenue reserve, including £45,942 for redemption of debenture stock, £745,942 (£667,751); first and second preference dividends, free of tax, £327,880; ordinary interim dividend, less tax, £198,583; final ordinary dividend of 7%, making 11% (same); £347,521; forward, £1,617,266 (£1,312,919).

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Raw Material Markets

Iron and Steel

Whereas basic and hematite pig-iron prices are up 2s. 6d. per ton, the authorised rise in the case of foundry and forge iron amounts to 3s. This differentiation, of course, is justified by the fact that foundry-iron prices were not varied in June last, when the quotations for basic and hematite iron were advanced by 4s. and 6s. per ton, respectively. Foundrymen would gladly pay the increased price if they could obtain adequate supplies, but at a time of acute stringency the output of high-phosphorus iron has been reduced. Unavoidable as this shrinkage may be, it is certainly ill-timed and will probably restrict the operations of the light foundries. Hematite, on the other hand, is rather more plentiful, and this enables the engineering and speciality foundries to maintain a high rate of activity.

Supplies to re-rollers are also a little more plentiful, and further improvement is anticipated when consignments from Belgium, purchased under the recent special agreement, begin to arrive. The more pressing need is for small 2-in. billets, but all classes of re-rolling material are wanted and there is still a brisk market for defectives, crops, etc., which can be used for various purposes.

It now appears to be definite that the shipbuilders' steel quota for the fourth period will be increased slightly. Although the shipbuilders claim that they could readily use 50 per cent. more material than they are at present receiving, any concession is welcome in an industry which has been seriously hampered by the shortage. All the plate and sheet mills have as much work in hand as they can execute before the end of the year and the modest advance of 3s. 6d. per ton on all heavy rolled-steel products is not likely to have any immediately restrictive effect on the demand.

Non-ferrous Metals

The British Bureau of Non-ferrous Metal Statistics has published copper consumption figures for July, which show a sharp decline in virgin metal, in comparison with June. Actually, the figure was 25,573 tons, as against 31,732 tons in the preceding month, and 27,758 tons in May. The July figure for secondary copper and copper in scrap amounted to 15,299 tons, compared with 16,656 tons in June and 16,393 tons in May. For the first half of the year, the monthly average consumption of virgin, bolstered up by a figure of nearly 37,000 tons in January, was 31,214 tons, but it is improbable that such a figure will be achieved during the second six months. August, a holiday month, is unlikely to improve on July, and, indeed, it is doubtful if it will be as good. True, the first half-year contained Easter and Whitsun, but the stoppage at Christmas will not be without effect. With regard to lead, it is disturbing to find that at the end of July total stocks in the country, *i.e.*, Government and consumers combined, amounted to no more than 22,312 tons. The consumption figure for July was 26,535 tons, against 29,241 tons in June, and therefore the country's stock, which is only about half of what it was at the beginning of the year, amounts to less than one month's cover at the present rate of usage. The zinc situation is reasonably good.

Business in non-ferrous metals remains quiet, and the seasonal summer lull seems to be projecting itself into the autumn. It is possible that the uncertainty of the international outlook is having an effect upon trade, while another problem is undoubtedly the very high prices for metals now obtaining all over the world. So far, in the United States, inflated values do not seem to have caused much trouble in the way of checking demand, but it is reported that in the retail trade the public is beginning to resist high prices, and this may well be the forerunner and warning of similar action in regard to commodities in general. Some weeks ago, it was apparent that on the Continent tin allocations were not being taken up so freely, and with the price where it is this is perhaps not very surprising. In spite of stockpiling, it is possible that tin will be the first metal to reach a balance between supply and demand, and thereafter it will not be long before there is too much tin in evidence. Producers of the metal talk complacently of stability at the present level, as if the consumer could be persuaded to pay an exorbitant price indefinitely.

New Companies

("Limited" is understood. Figures indicate capital. Names are of directors unless otherwise stated. Information compiled by Jordan & Sons, 116, Chancery Lane, London, W.C.2.)

Tom Martin & Company (Blackburn), 2, Heaton Street, Blackburn—Non-ferrous metal merchants, etc. £9,000.

Henry Robinson (Ironfounders), Stewkins Foundry, Kingswinford, near Stourbridge—£17,000. R. C. Robinson and J. H. Folkes.

D. V. Howells & Sons, Observatory, Milford Haven—Metal and scrap merchants, etc. £1,000. D. V., H. J. H. and M. V. Howells.

Henderson & Glass, 26, Regent Road. Liverpool—Iron and steel merchants, etc. £60,000. R. Glass, senr., R. Glass, junr., and J. T. N. Wilson.

Johnson & Hartley, 335-9, Corn Exchange Buildings, Manchester, 4—Manufacturers of textile machinery and accessories, etc. £10,000. A. Johnson, J. A. Hartley, B. B. Dearden and J. R. Foulkes.

GODFREY TWACHTMAN & COMPANY, 913, Main Street, Kansas City, Missouri, U.S.A., wishes to import approximately 100,000 18 in. to 26 in. agricultural discs. Firms interested should contact the company direct.

THE PARTNERSHIP BETWEEN John Edward Dalton and John Williamson, carrying on business as founders, at Grange Foundry, Town Street, Ferrybridge, Yorks, under the style of Williamson & Dalton, has been dissolved.